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# **The Appearance of Beam Lines**

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# The Appearance of Beam Lines

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## Abstract

The combination of an existing graphics package with a large program like TRANSPORT<sup>1</sup> has often resulted in considerable modification to the large program. Use of other graphics packages has resulted in essentially having to repeat the work. This difficulty has been avoided in a modification of TRANSPORT which produces layouts of beam lines. Drawings of the reference trajectory and three-dimensional images of all magnets are made by the graphics package TOP DRAWER<sup>2</sup>. Nothing specific to TOP DRAWER or any other graphics package has been incorporated into TRANSPORT. If a user is familiar with a different graphics package he or she can then begin usage of this alternate package essentially immediately.

## 1 TRANSPORT Input Data

A section of a charged-particle optical system may be represented in the input data for the computer program TRANSPORT as:

```
DRIFT 0.5
QUAD .25 5.0 .5, TYPE = PUCE ;
DRIFT 0.25 ;
QUAD .25 5.0 .5, TYPE = PUCE ;
DRIFT 0.25
SBEND .7405 9. .5, TYPE = MAUVE ;
DRIFT 0.25 ;
QUAD .25 5.0 .5, TYPE = PUCE ;
DRIFT 0.25 ;
```

The elements DRIFT, QUAD, and SBEND are listed in the same order in the data as they occur in the beam line. The element SBEND is a sector bending magnet including the fringing fields at the entrance and exit. A rectangular bending magnet, given the designation RBEND, is also available in TRANSPORT.

The first number after each literal mnemonic (DRIFT, QUAD, SBEND) is the physical length of that element. The second number on the magnetic elements is the strength of the magnetic field. Using the magnetic field strength and the reference trajectory momentum (given

elsewhere in the data), one can now determine the floor coordinates of the reference trajectory. The third number on the QUAD elements is the aperture radius. The third number on the SBEND element is the normalised field gradient  $n$ .

The final item on the magnetic elements is the type specification. It can be used for reference to other specifications about the magnet, as we shall see below.

## 2 Specifying a Plot

Using TRANSPORT, a plot may now be made of the floor coordinates of the reference trajectory. This is done by placing the instruction

```
PLOT, ZFLOOR, YFLOOR ;
```

in the input data before any of the physical elements. This instruction produces a layout of the  $y$  and  $z$  coordinates. The  $y$  coordinate is taken as vertical. The  $z$  coordinate is taken as being along the initial direction of the reference trajectory, unless another initial direction is specified in the input data. Layouts may also be produced in the  $x$  and  $z$  coordinates.

It is much more interesting and useful to be able to draw the magnets with their physical dimensions as they sit on the reference trajectory. For this purpose, it is essential to know their dimensions. Here the type designation described above allows the dimensions of a magnet to be specified by type. Dimension specifications for the magnets mentioned above might be given in the data as:

```
MAGNET, HEIGHT = .20, WIDTH = .30, TYPE = MAUVE ;
MAGNET, HEIGHT = .25, WIDTH = .25, TYPE = PUCE ;
```

There can be many different types of quadrupoles, bending magnets, sextupoles, and octupoles. The same set of data could also have quadrupoles which are SAFFRON, INDIGO, OCHRE, or AVOCADO. A type designation can consist of any combination of letters and numerals up to

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fifteen characters.

The illustrations with this article were made using the plotting package TOPDRAWER. However, there is nothing in TRANSPORT that is specific to TOPDRAWER. Similarly, there is nothing in TOPDRAWER that is in any way specific to TRANSPORT. If a TRANSPORT user is familiar with a different plotting package, he or she may switch over to that package without making any alterations in the TRANSPORT input or output or the program itself.

A skeleton data set for TOPDRAWER might look like:

```
SET LIMITS X -1.0 2.5
SET LIMITS Y -0.75 1.25
SET SCALE X LINEAR
SET SCALE Y LINEAR
TITLE TOP SIZE 2 'SECTOR BENDING MAGNET'
SET ORDER X Y
DATA
JOIN 1
STOP
```

The first six lines give the range of the coordinates, the type of scale, the title, and which coordinate is horizontal and which vertical. The word DATA is not a TOPDRAWER instruction. It indicates the location of the data to be plotted. The PLOT instruction in TRANSPORT produces an output file which is separate from the usual TRANSPORT output. A short auxiliary program exists which replaces the word DATA in the TOPDRAWER skeleton file with the contents of the TRANSPORT output file.

The execution of TRANSPORT, that of the short auxiliary program, and of TOP DRAWER can all be combined in a single procedure. The user need then only set up the TRANSPORT data set, including the PLOT instruction, and the TOP DRAWER skeleton data set, and then invoke the procedure. The TRANSPORT output will automatically be combined into the TOP DRAWER skeleton deck and plots will be produced.

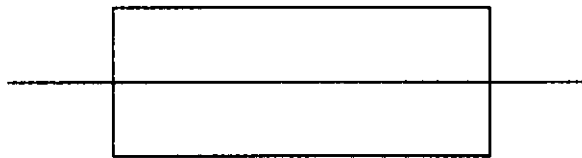
The instruction JOIN 1 indicates that the points are to be joined by straight line segments. The instruction STOP indicates that there are no more instructions. Once the word DATA has been replaced by the file produced by TRANSPORT, the resulting set of data is a complete TOPDRAWER input data set.

TRANSPORT users will recall that several passes through a beam line or passes through several beam lines can be made in a single run of TRANSPORT. These multiple passes can all be plotted in the same job, either on the same plot or on several. The set of two commands DATA and JOIN 1 needs merely to be repeated as many times as there are passes in the job.

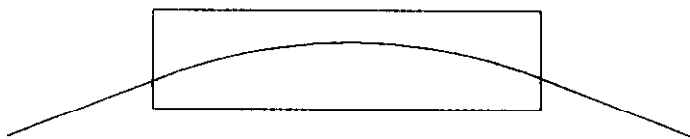
### 3 Simple Components

A quadrupole or an RBEND as seen from the side is a simple rectangle which is bisected by the reference trajec-

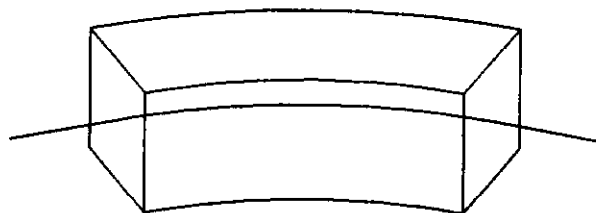
tory. It might look like:



From above an RBEND is still rectangular, but the bend can be seen in the reference trajectory. The sagitta correction is made automatically. The appearance would then be:

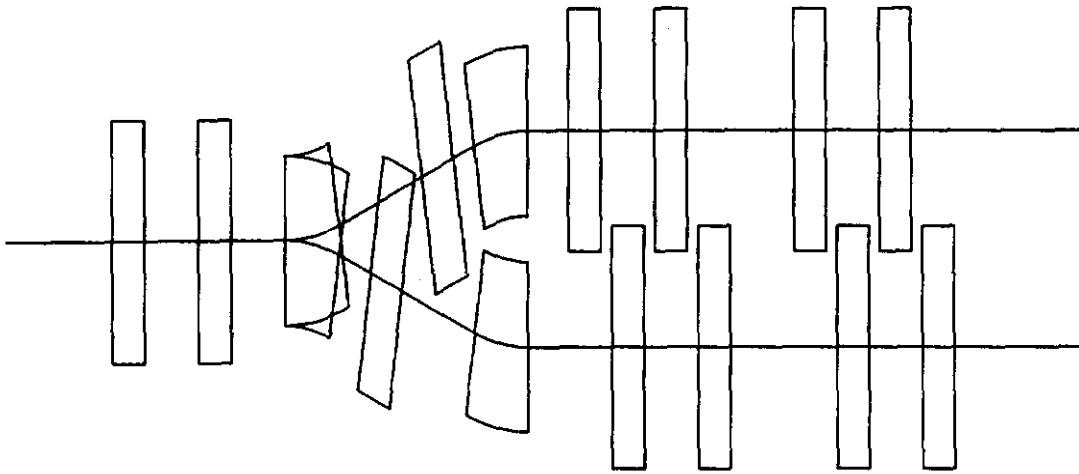


The elements can be rotated about the reference trajectory to give three-dimensional views. Such a view for an SBEND would be:

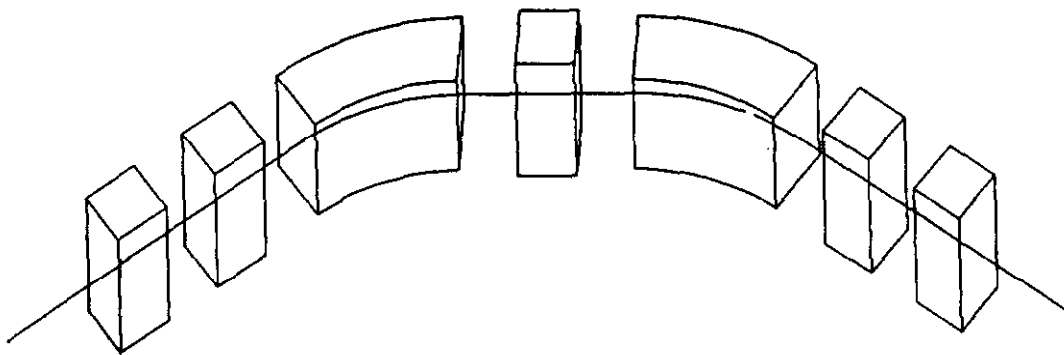


Two larger illustrations of sets of elements can be found on the next page.

- [1] D.C. Carey, K.L. Brown, F. Rothacker, and Ch. Iselin, "TRANSPORT, A Computer Program for Designing Charged Particle Beam Transport Systems", SLAC Report SLAC91.
- [2] R.B. Chaffee, "Introduction to Top Drawer", SLAC Computation Group Report CGTM No. 189.



A switch in a beam line. Here the beam plots from two successive TRANSPORT runs are on the same plot. The beam lines have been designed so that the magnets do not collide.



A view of a simple beam line. The reference trajectory is given an initial upward direction. The coordinate system is also rolled about the reference trajectory. The view then seems to be three-dimensional.